

REDUCED RISK MANAGEMENT OF INSECT PESTS IN SUGARBEETS

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SUBMITTED BY:

California Beet Growers Association
Ben Goodwin, Executive Manager
2 W. Swain Road
Stockton, California 95207-4395
Phone: (209) 477-5596
Fax: (209) 477-1610
Email: cbga@cwnet.com

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Prepared for California Department of Pesticide Regulation

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ACKNOWLEDGMENTS

California Beet Growers Association:

Ben Goodwin, Executive Manager

University of California Cooperative Extension:

Dr. Stephen Kaffka, Sugarbeet Specialist, Extension Agronomist, Department of Agronomy and Range Science, U.C. Davis

Dr. Larry Godfrey, Extension Entomologist/Associate Entomologist, U.C. Davis

U.C. Armstrong Plant Pathology Field Station staff

University of California Cooperative Extension Farm Advisors:

Fresno County UCCE

Tom Turini, Imperial County UCCE

Yolo County UCCE

Pest Control Advisors:

Greg Renna, Airway Farms

Tom Rutherford, Rutherford Farms

Spreckels Sugar Company personnel:

John Adamek, Field Representative, Spreckels Sugar Company, Brawley, California

Tom Babb, formerly Chief Agronomist, Spreckels Sugar Company, Woodland, California;
now Department of Pesticide Regulation

Dr. James Gerik, Research Plant Pathologist, Imperial Holly Corporation, Tracy, California

Richard Heimforth, Field Representative, Spreckels Sugar Company, Mendota, California

Dave Melin, Agricultural Manager, Spreckels Sugar Company, Brawley, California

Alan Telck, Manager, Beet Quality Improvement Projects, Holly Sugar Corporation,
Sheridan, Wyoming

Field Assistants:

Elias Bassil; Elaine Cho; Jorge Cisneros; David Haviland; Gary Peterson

PMA Demonstration Site Coordinators:

Airway Farms, Fresno County

Rutherford Farms, Tom and Curt Rutherford, Imperial County

U.C. Armstrong Plant Pathology Field Station, Yolo County

Industry Supporters:

Betaseed, Inc.; Britz Fertilizers, Inc.; California Sugarbeet Industry Research Committee;

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ABSTRACT

The Sugarbeet Pest Management Alliance (PMA) was formed in 1998 by the alliance of the California Department of Pesticide Regulation (DPR), the California Beet Growers Association (C.B.G.A.), Spreckels Sugar Company, and the University of California Cooperative Extension.

The purpose of the alliance is to evaluate alternative sugarbeet insect pest management with reduced risk pesticides in response to the regulatory actions of the Food Quality Protection Act (FQPA). The DPR funded this demonstration project with a grant of \$88,841 for the period June 15, 1999, to March 31, 2001. Additional to the alliance are university researchers, sugarbeet growers, and pest control advisors (PCA), and within the alliance are a regional manager, a management team, and cooperating farm advisors.

Project objectives are the demonstration of reduced risk management of sugarbeet armyworm and improving sugarbeet stands and reducing pesticide use in the Imperial Valley. Field scale, strip, and plot size trials were established in conducting the applied research studies.

Two field scale trials in Fresno County provided for demonstration of beet armyworm population monitoring and comparison of reduced risk insecticide application versus standard grower practice in management of beet armyworm populations. A trial plot at the Armstrong Plant Pathology Field Station on the U.C. Davis campus, Yolo County, provided for demonstration of economic thresholds in justifying the application of chemical control insecticides based on observation of plant foliar and crown damage from beet armyworm.

Fifteen strips (five treatments times 3 replications) were established in Imperial County to demonstrate alternative sugarbeet seedling protection strategies. In this study, pre-emergence seedling protection, utilizing treated seed, was compared to standard grower practices, which incorporate greater use of chemical controls in crop establishment.

The demonstration in Fresno County showed that more effective reduced risk materials would aid a management program incorporating beet armyworm population monitoring. This would provide effective pest control and conserve beneficial insects to reduce build-up of secondary pests.

The Yolo County plot showed that a more refined treatment threshold would be of benefit in helping growers to concentrate pest control treatments at critical times. This would also encourage grower adoption of higher cost, low risk materials if timely treatment produced desired results.

The Imperial County trial demonstrated that pre-emergence seed treatments can be effective as a seedling protection strategy. Utilization of a seed treatment strategy in seedling establishment may also assist in the reduction of pesticide use in overall crop establishment.

EXECUTIVE SUMMARY

The beet armyworm (*Spodoptera exigua*) has been identified as the most important sugarbeet pest in recent years. This pest reduces seedling density (stands), defoliates plants and feeds on the sugarbeet root. Presently, growers manage beet armyworm larvae with foliar applications of primarily chlorpyrifos (Lorsban®) and methomyl (Lannate®), which are susceptible to FQPA regulatory actions. The overall goal of this project is to demonstrate improved integrated management of insect pests through reduced application of insecticides and preservation of beneficial insects.

These demonstrations were conducted at the U.C. Davis campus and in the south San Joaquin Valley and Imperial Valley. Beginning in 2001, sugarbeet production will be concentrated in the South San Joaquin Valley (Merced County to Kern County) and the Imperial Valley due to beet factory closures at Tracy and Woodland, California, in December 2000. Objective 2 of the plan was summarily canceled for this reason.

The objectives of the sugarbeet PMA are: 1) to demonstrate reduced risk management of sugarbeet armyworm; 2) to demonstrate improving sugarbeet stands and reducing pesticide use in the Imperial Valley; and 3) to improve pest management decisions through Internet accessible keys.

A field scale trial using traditional and biorational techniques to manage beet armyworm was established. One half of the field was treated by traditional means (chlorpyrifos and methomyl), and the other half was monitored using pheromone trapping techniques and sprayed with reduced risk materials when beet armyworm larvae were most susceptible. Sweep netting was incorporated to monitor secondary pest problems and effects on beneficial populations between the traditional and reduced risk material applications. An integral part of this research was to provide growers and PCA's with an easy and effective method of monitoring target pests to optimize insecticide application. Effective monitoring facilitates treatment timing in the most efficacious manner.

Seedling protection in establishing stands in the harsh environment of the Imperial Valley is of paramount importance to growers. Traditional grower practice requires multiple insecticide treatments in establishing plant populations. These are both pre- and post-emergent. Strip trials were established to demonstrate seedling protection using grower preferred treatments and seed treated with an application of the reduced risk systemic insecticide imidacloprid (Gaucho®). Utilization of this seed treatment protects seedlings against certain pests that must otherwise be controlled by insecticide application.

The sugarbeet PMA successfully demonstrated that biorational control of beet armyworm has merit when coupled with improved, effective pest monitoring techniques. Success was achieved as well in alternative seedling protection through application of a reduced risk material as a seed treatment.

This strategy also indicated the potential for reduction of insecticide applications currently made under the preferred grower practice.

In conclusion, improved integrated management of beet armyworm in sugarbeets is warranted, and usable damage thresholds and monitoring techniques must be developed to achieve this goal. In addition more effective reduced risk materials must be used to aid in the development of this IPM program. *Reduced risk systemic materials, applied as a seed treatment, demonstrate clearly the benefits of this strategy in both protection of seedlings and reduction of the number of pesticide applications necessary for crop establishment. More effective reduced risk materials may expand the scope of insect control, when used as a seed treatment, further enhancing environmental benefit.*

Reduced Risk Management of Insect Pests in Sugarbeets

Objective 1: Demonstration of Reduced Risk Management of Sugarbeet Armyworm: L. Godfrey and T. Babb

Introduction. Beet armyworm (*Spodoptera exigua*) larvae remain a significant insect pest of sugarbeets in the Central Valley. This species has a wide host range and is a significant pest (in addition to sugarbeets) on tomatoes, cotton, cucurbits, alfalfa, lettuce, and other crops. Beet armyworm eggs are deposited in clusters of ~100 on the leaf surface. Egg masses are covered with hairlike scales. Newly-emerged larvae feed in a cluster initially and then move apart over the plant. The larvae skeletonize plant leaves leaving the veins. On sugarbeets, this defoliation can cause significant yield losses. In addition, in recent years the larvae appear to feed in more protected areas as opposed to populations in the 1970's and 80's, for instance. This behavior was noted by Dr. Harry Lange in his review of sugarbeet insect pest management (Lange 1987). This has resulted in the larvae often feeding on the beet roots near the soil surface or slightly below the soil surface (larvae crawl into soil cracks caused by the roots). This root feeding provides entry ports for root rotting organisms into the beet roots. These root rot diseases can quickly decimate a sugarbeet stand or nearly mature crop. Finally, beet armyworm larvae also inhibit sugarbeet seedling establishment by clipping emerging seedlings. This can result in inadequate stands or replanting.

Control of beet armyworm infestations during the growing season is largely accomplished with applications of organophosphate and carbamate insecticides (primarily Lorsban® and Lannate®). Insecticide usage was evaluated in Fresno and Imperial counties from 1995 to 1999 in order to provide a baseline at the initiation of this project (C-DPR PUR data). Insecticide use (pounds active ingredient applied per harvested acre and number of acre treatments) increased over this period in Fresno Co. from 1.5 and 1.8 (1995) to 2.8 and 3.6 (1999) for the pounds and number of application parameters, respectively (Table 1). The largest increase was from the 1996 to 1997 seasons. The applications were ~50% organophosphate from 1995 to 1997 and that percentage increased to ~60% in 1998 and 1999. There has been a concomitant decline in the use of carbamates (~40% of the applications from 1995 to 1997 and down to ~30% from 1998 to 1999). The use of biologicals, although never very high, has also declined from a high of 7.4% of the applications in 1996 to 0.7% of the applications in 1998 (Table 1). Pyrethroid use has increased to ~7% of the applications (1999). In Imperial Co., insecticide use on sugarbeets has stayed fairly constant from 1995 to 1999 (Table 1). The pounds active ingredient applied per harvested acre has averaged 4.1 (range of 3.2 to 4.5) and the number of acre treatments has averaged 6.8 (range of 6.0 to 7.8). Use of organophosphate insecticides has declined from 1995 to 1999 from 75.1% to 63.0% of the applications. This decline has been offset by an increase to the use of carbamates (11.7 to 17.2% of the applications) and pyrethroids (13.2% of the applications in 1995 under a Section 18 registration to 17.5% of the applications in 1999). The use of biological insecticides in Imperial Co. is negligible (peak of 1.4%).

In recent years in the Central Valley, repeat applications of insecticides are often needed and control has still been inadequate. These applications have eroded the profitability of sugarbeets and the lack

of control has reduced the sucrose yields. In addition, the multiple applications have flared populations of secondary pests such as spider mites, leafhoppers, etc. In many areas, the beets are nearly completely defoliated by about 1 month before harvest. The plants regrow at this time, which utilizes stored energy that could go into sucrose at harvest. The susceptibility of new, high yielding sugarbeet varieties to beet armyworm defoliation is unknown. These varieties have a unique genetic background compared with older varieties and have a different leaf architecture (heavier canopy). These factors may influence the crop response to defoliation. Suh (1980) evaluated the effects of defoliation on sugarbeet yield in the late 1970's. His results showed the plants were extremely resilient of damage and that acceptable yields could be produced in spite of severe (nearly 100% in some cases) defoliation. His studies, however, had many limitations and the results were never implemented or accepted by growers.

Parasitoids, *Hyposoter exigua*, predators, and virus diseases potentially inflict a high degree of natural control on beet armyworm populations. However, given the high populations and the need for quick control, these have not been important factors in the Central Valley. The efficacy of the organophosphate insecticides appears to be waning probably because of the development of resistance. Resistance to these materials has been verified in vegetable systems. In addition, the regulatory actions of FQPA may limit use of these products. The development and use of adoptable thresholds would allow growers to lower insecticide use by maximizing the natural ability of sugarbeet plants to compensate for defoliation. Decreased insecticide use would in turn reduce the incidence of secondary pest outbreaks by not disrupting naturally occurring biological control organisms. Therefore, there is a need to design alternative, improved IPM programs for beet armyworms on sugarbeets in the mid and southern San Joaquin Valley.

Materials and Methods

Work for this objective was conducted in two locations. Tasks 1 and 3 were done in Fresno Co. and Task 2 was done in Yolo Co.

Tasks 1 and 3.

A demonstration project was conducted in Fresno County to attempt to manage beet armyworms using biorational means in comparison with the standard grower practice. Two late fall/winter planted fields were utilized in which the biorational practices were used on 30 acres compared with the standard practices on the remaining ~130 acres. The PCA was involved in making decisions on the grower-practice side and we (Babb and Godfrey), in concert with the PCA, made management decisions on the biorational side. The concept for the biorational management was to use pheromone traps to monitor the beet armyworm moth flights and to make visual inspections of foliage for egg masses. The control tactic was to use B.t. sprays (Lepinox® or XenTari®) at the onset of egg hatch. This would concentrate the activity of B.t. onto the early instars, where it is most effective. The grower practice was to use repeated applications of Lannate®, Lorsban®, or other organophosphate/carbamate insecticides.

The following samples were collected on a weekly interval (irrigation and/or chemical treatments prevented sampling on a few dates).

- 1.) wing/sticky pheromone traps baited with BAW pheromone were placed in each field on 6 June.
- 2.) bucket pheromone traps baited with BAW pheromone were placed in each field on 14 June.
- 3.) sweep net samples were taken in each field (grower and biorational portions as soon as this segregation occurred), samples were taken to the laboratory and the numbers of beet armyworm larvae, *Empoasca* leafhoppers, and beneficials (lygus bugs, stink bugs, minute pirate bugs, big-eyed bugs, assassin bugs, damsel bugs, lacewings, lady beetles, collops beetle, parasitic wasps, and spiders) were counted.
- 4.) visual inspections were done on 20 leaf samples in each field to assess the numbers of beet armyworm egg masses and larvae.
- 5.) leaf samples for spider mites were collected on 9 Aug.; samples were processed in the laboratory with a washing technique.
- 6.) harvest samples (from a commercial harvest) were collected in October from both fields and from the biorational side and the grower standard side)
- 7.) sucrose content was determined at the Spreckels tare laboratory and sucrose yields were calculated.

Task 2

Sugarbeets were planted on May 12 and grown according to standard grower convention at the Armstrong Plant Pathology Field Station on the UC Davis Campus. The experimental plots were 6 rows wide, with two rows representing fall 2000 harvest, two rows for spring 2001 harvest, and the other two rows acting as borders. Two studies were conducted; plots were 17 feet long for the artificial inoculation experiment and 30 feet long for the natural population experiment. Plots were organized in a randomized complete block design with 4 repetitions of each treatment.

Plant damage was evaluated through weekly leaf area measurements as well as harvest evaluations of tonnage, sucrose content, and root rot incidence. Weekly leaf samples consisted of 10 of the first fully expanded leaves taken from random plants in each plot. Area measurements were recorded for each individual leaf using a Li-Cor LI-3100 leaf area meter. Harvest evaluations were completed from October 25 to 27, 2000. Plots were mechanically topped and lifted and then manually counted and weighed. Beet samples were sent to the Spreckels Sugar Company tare lab for sucrose analysis and clean beet percentage.

For the artificial inoculation study, beet armyworm densities were established through the artificial inoculation of armyworm eggs suspended in corn cob grit. Plants were inoculated 1, 2, or 3 months before fall harvest with 0, 20, 40, 80, or 120 eggs per plant. Malathion applications were used one week before each inoculation date to minimize predation on eggs. Two additional treatments were manually defoliated 1 and 2 months before harvest to serve as checks.

For the study which aimed to manipulate natural populations of beet armyworm larvae through the use of insecticide applications, natural armyworm populations were allowed to establish in the plots

from planting on May 12 until July 27. A single Lorsban® application was sprayed on June 19th to aid in sugarbeet seedling establishment, i.e., reduce stand loss from beet armyworms. Treatments of different armyworm densities were established through the use of the insecticide Success®. During the three months preceding fall harvest, each plot received from 0 to 4 applications of Success® at 6 oz./acre. Single application treatments were established to represent early (July), middle (August), and late-season (September) control. Additional treatments represented season-long control at a low rate (2 applications) and a high rate (3-4 applications) as well as unsprayed control plots. Weekly sweep net samples in individual plots were used to monitor within plot differences of armyworm densities.

Results

Tasks 1 and 3.

Pheromone traps: Beet armyworm flights occurred about 3 weeks earlier compared with normal. That was seen in research plots near Davis and noted by PCAs in the San Joaquin Valley. Moths were captured during the first sample period (6-14 June) and this appeared to the declining side of the first BAW flight (Fig. 1). The peak of the second and third flights occurred in mid-July and mid-August, respectively. The bucket traps captured many more moths than the sticky trap from July to Sept. For the first few sample periods, the bucket trap was not effective. Overall, the bucket trap withstood field conditions better than the wing trap, i.e., was not hindered by dust, and collected more moths. The high moth captures could however be a downside as counting the 1000+ moths captured in one week was not quick or easy.

Research in cotton has shown that ~930 degree-days (882 for females and 977.9 for males) (54°F lower threshold) are needed for development of BAW from egg to adult. The developmental rate on sugarbeets is unknown (developmental rates can vary significantly among hosts). Using 1 June as the estimated initial date of oviposition, the new adults should appear about 14 July and the next generation adults should appear on 23 Aug. These approximate our trap captures well.

Field Treatments: The treatments as shown in Table 2 were applied to the biorationally managed and grower managed areas.

The first application was made primarily for sugarbeet webworms. Lepinox® was also applied to the grower managed side on this date. The 13 July and 21 July applications were made for beet armyworms, as well as the 28 August application made only in the grower-managed side. The M-Pede® was included to reduce spider mite numbers.

Sweep Net Samples: Sweep net samples from the biorationally-treated area and the grower-treated area (28 June and once treatments had been applied) showed initially a high number of beneficials followed by a gradual decline in both treatments to no beneficials on 9 August (Fig. 2). This corresponds to the time when the sugarbeet tops were decimated in both treatments. This made collecting sweep net samples difficult and also made the field not conducive to beneficials.

Leafhopper populations built-up to significant levels in both treatments (Fig. 3). Populations started at ~50 per 50 sweeps on 14 June and peaked at ~300 per 50 sweeps in mid-July. Levels declined thereafter to less than 20 per 50 sweeps. There were no consistent trends between the two treatment regimes. The leafhopper threshold is based on leaf turn samples (threshold being ~15 leafhoppers per leaf). Preliminary research has shown that 1 leafhopper per leaf turn \approx 50 per sweep. Beet armyworm larval data from the sweep net samples showed very low populations until 5 July (Fig. 4). These were likely larvae that arose from the moths captured by pheromone traps in mid-late June. The rationale being that for the moths in pheromone traps it would take a few days (3-5) for them to mate, develop and deposit eggs, ~4-5 days for the eggs to hatch, and 7-10 days for the larvae to develop to the third instar. The early instars feed more commonly in a webbing in a mass and may not be adequately sampled with a sweep net. Larval populations remained at 5 or less per 50 sweeps in the grower treated area but peaked at 26 per 50 sweeps in the biorationally-managed area.

Visual Inspections: Inspections of sugarbeet leaves revealed very few larvae and/or egg masses. The highest count was 3.25 larvae per 20 leaves on 24 July in the biorational treatment. The larvae are reclusive during the heat of the day.

Damage Observations: Defoliation damage was minimal during June and early July. Sugarbeet webworm, *Loxostege sticticalis*, populations were present during this time and damaged the plant terminals. In mid-July, some moderate defoliation damage was noted and the leaf health started to decline noticeably. Leafhopper feeding and spider mite damage contributed to this decline. The heat was also a factor as daily high temperatures averaged over 100°F from July 28 to August 6. By ~9 August, the entire leaf canopy in both fields and both treatments was photosynthetically nonfunctional. The remaining leaves were chlorotic or dead. Some leaf regrowth occurred from 25 Aug. and by 8 Sept. the plants had a small cluster of leaves (6-8).

Mite Counts: Spider mites can be an important pest of sugarbeets. The exact effects of spider mites on beet yield have not been quantified, but based on observational data the effects can be significant. In addition, we have seen cases where spider mite populations develop following application of broad-spectrum insecticides. Leaf collections (20 leaf sample) from 9 August showed that there were 4700 mites per sample from the grower standard field portion and 3590 mites per sample from the biorationally-treated field section.

Yields: Sugarbeet yields and sucrose contents were variable across treatments and across fields (Table 3). In both fields, the percentage sucrose was slightly greater in the biorationally-managed plot compared with the grower standard. However, beet yields were variable, i.e., each treatment had the advantage in terms of beet yield in one of the two fields. Sucrose yield was higher for the biorational treatment than the grower standard in field 2 and the inverse was true in field 1 (Fig. 5).

Task 2

Among the different treatment levels at any given date or among inoculation dates (Table 4), significant differences were found when comparing inoculated plots with plots artificially defoliated one month or two months before fall harvest. This suggests that even one complete defoliation event can be sufficient to significantly reduce all yield components, and that inoculated armyworm densities were insufficient to produce the damage equivalent to one such defoliation event. The trial was unable to determine if the observed damage resulted in sufficient economic losses to justify the application of chemical insecticides.

Field observations attribute the low damage to poor survivorship of armyworm eggs. Eclosion (in the absence of predators and parasites) averaged 18.5% (July), 34.0% (August), and 17.8% (September). This is the equivalent of 22.2, 40.8, and 21.4 first instar larvae per plant in the 120 egg treatment. Yet, despite these high rates of inoculation, field data from three days after each inoculation date reported nearly 100% mortality of armyworm larvae. This included over 600,000 eggs over three inoculation dates at rates up to over 4 million eggs per acre.

Weekly sweep net samples averaged across all treatments of armyworm densities after Success applications showed a direct relationship between worm density and period of time after insecticide application. At 1 to 3 weeks after application, the beet armyworm population was nearly eliminated compared with levels up over 7 per 40 sweeps at 7+ weeks after treatment (Table 5). The untreated plots averaged 3.3 larvae per 40 sweeps. Season-long treatments of 2, 3, and 4 applications provided the best overall control. Highest worm densities varied according to date and application timing. Even the highest infestation level, though, proved insufficient to reach economic injury levels since no significant yield differences were observed. No significant differences were found in leaf area, sucrose percent, tons/acre, or sucrose/acre between the single and multiple application treatments (Table 6). Also, no significant differences were found among early, middle, and late season control treatments. Data from this experiment does suggest that no significant losses occur for one time density counts of 7 larvae per 40 sweeps in August, 14 larvae in September, and 9 larvae in October (Fig. 6). Also, no significant differences were found for cumulative damages of 3.3 larvae per 40 sweeps over the 11 weeks before fall harvest.

Discussion

For the Fresno Co. study, pheromone trap catches and degree-day accumulations were generally in agreement. The armyworm flight began relatively early in 2000 and the first generation (June) was unusually high. These sampling tools (traps) seemed to foretell the timing of infestations; however, we were unable to find any numbers of larvae and egg masses on the plants. Based on plant damage and beet yields one could say the biorational treatment was equal to the conventional treatment. However, neither strategy provided acceptable management of beet armyworm and/or the secondary pest complex in 2000. By late July, plants were entirely defoliated with both approaches.

In Yolo Co., general observations suggest that predation of beet armyworm eggs and larvae, primarily by minute pirate bugs (MPB), was a primary cause of larval mortality. Despite malathion applications, minute pirate bug populations commonly reached nearly one per plant, and could be

observed actively searching and feeding on small larvae. It is supposed that the pirate bugs were able to increase by feeding on spider mites, eventually causing them to crash completely during the mid-season without a single miticide application. Pirate bugs then used armyworm eggs and young larvae as a food source. The net effect was a lack of treatment differences, thus resulting in no significant differences among treatment levels or among treatment dates. Natural armyworm densities were insufficient, particularly mid to late season, to cause detectable losses in yield data. Pheromone trap catches at the Armstrong Plant Pathology Farm showed three armyworm flights, each of decreasing magnitude throughout the season (Fig. 7). During most years, each successive peak is greater in magnitude with highest worm pressures resulting in late summer. Highest trap catches this year were observed between late-June and mid-July, with peak populations of 140 adults during the week of July 10-17. The first Success® application was sprayed on July 27. Later flights in August and October reached peaks of 69 and 40 adults per weeks ending August 29 and October 4 respectively. As a comparison, some armyworm traps in sugarbeet fields of the central valley of California during the same time periods consistently caught over 1000 adults per week. High levels of biological control within the field probably also contributed to low pest densities in the treatment timing study. By using a selective armyworm insecticide, pest outbreaks common with organophosphate and carbamate use were avoided. This was confirmed in both experiments by mid-season crashes of mite populations. Mite populations on August 10 were high enough to debate the need of a miticide application. By September 5, both mite and armyworm populations had disappeared completely without the application of a single miticide.

Summary and Conclusions

The use of pheromone traps with degree day accumulations showed promise for beet armyworm. More effective reduced risk materials would aid this management program. Ideally, these materials would provide effective pest control and conserve populations of natural enemies which would reduce the build-up of secondary pests such as spider mites. A more refined treatment threshold would also be helpful. This would allow growers to concentrate treatments when they are most critically needed. This is important given the elevated costs of most of the reduced risk materials and this information would facilitate adoption. Otherwise, "blanket" treatments of cheaper, traditional materials may continue to be the favored strategy. We were not able to establish economic injury levels for beet armyworm during this research year. This was due in part to high levels of biological control as well as low general insect pressure. We did, though, make valuable observations regarding the interactions among armyworms, mites, and beneficial generalist predators. We also determined that at the levels of armyworm infestations present in these experimental plots this year in Yolo Co., all uses of chemical insecticides for armyworm within three months of harvest were not economically justifiable.

Table 1. Insecticide use patterns on sugarbeets, Fresno and Imperial Counties, 1995-1999.

	1995	1996	1997	1998	1999
<u>Fresno Co.</u>					
Pounds Active Ingredient Applied per Harvested Acre	1.5	2.0	3.8	2.6	2.8
Number of Acre Applications	1.8	2.5	4.8	3.1	3.6
Acres Applications - % Organophosphates	54.7	50.1	49.8	64.3	57.2
Acres Applications - % Carbamate	39.8	42.3	41.8	34.1	31.4
Acres Applications - % Pyrethroids	0	0	0.2	0.2	7.3
Acres Applications - % Biologicals	5.1	7.4	5.4	0.7	3.4
<u>Imperial Co.</u>					
Pounds Active Ingredient Applied per Harvested Acre	4.1	4.5	4.2	3.2	4.3
Number of Acre Applications	7.1	6.9	6.2	6.0	7.8
Acres Applications - % Organophosphates	75.1	80.0	78.2	67.7	63.0
Acres Applications - % Carbamate	11.7	16.5	19.9	15.8	17.2
Acres Applications - % Pyrethroids	13.2	0	0.0	16.2	17.5
Acres Applications - % Biologicals	0.0	0.0	0.4	0.3	1.4

Table 2. Treatments applied in beet armyworm management project, Fresno Co.

Biorational Plot	Product	Rate (per acre)	Grower Standard Plot	Product	Rate (per acre)
29 June	Lepinox®	1 lb.	29 June	Lepinox®	1 lb.
13 July	XenTari®	2 lbs.	13 July	Lorsban® 4E	1 qt.
21 July	Lepinox® + M-Pede®	2 lbs. + 0.5 gal.	21 July	Lorsban® 4E	1 qt.
			28 August	Lorsban® 4E + M-Pede®	1 qt. + 0.5 gal.

Table 3. Sugar beet yields across fields and treatments, Fresno Co., 2000.

Field	Treatment	Beet Yield (t/A)	% Sucrose	Sucrose yield (t/A)
1	biorational	24.53	14.1	3.46
1	grower standard	40.02	13.1	5.24
2	biorational	41.01	12.4	5.1
2	grower standard	33.89	11.9	4.03

Table 4. Harvest data for artificial defoliation experiment.

Month	Eggs per 6 row inches	Leaf area at harvest (cm ²)	Tons/acre	Sugar (%)	Sucrose (tons/acre)
July	0	93	27.6	12.8	3.53
July	20	100	28.5	13.2	3.77
July	40	98	28.2	13.3	3.74
July	80	104	29.7	13.6	4.02
July	120	101	28.6	13.3	3.79
August	0	98	27.3	13.3	3.63
August	20	115	28.9	13.2	3.82
August	40	101	27.2	13.3	3.63
August	80	117	28.8	13.1	3.76
August	120	104	26.1	13.6	3.55
September	0	108	27.6	12.8	3.53
September	20	81	28.5	13.2	3.77
September	40	111	28.2	13.3	3.74
September	80	102	29.7	13.6	4.02
September	120	111	28.6	13.3	3.79
August	Manual defoliation	92	24.8	12.7	3.12
September	Manual defoliation	101	26.4	12.2	3.24

Table 5. Density of armyworms collected in sweep net samples after applications of Success.

Weeks after application	1	2	3	4	5	6	7	8	None *
Larvae per 40 sweeps	0.2	0.2	0.1	1.3	1.7	3.5	7.0	7.3	3.3

* Average of untreated plots for weeks 1-8.

Table 6. Harvest data for application timing experiment.

Month	Number of applications	Harvest leaf area (cm ²)	Tons/acre	Sugar (%)	Sucrose (tons/acre)
No control	0	115	24	13.0	3.10
July	1	104	22.6	13.3	2.99
August	1	119	23.4	13.1	3.08
September	1	122	22.6	12.9	2.90
Season-long moderate intensity	2	120	22.8	13.1	2.99
Season-long high intensity	3 or 4	110	22.5	13.1	2.95

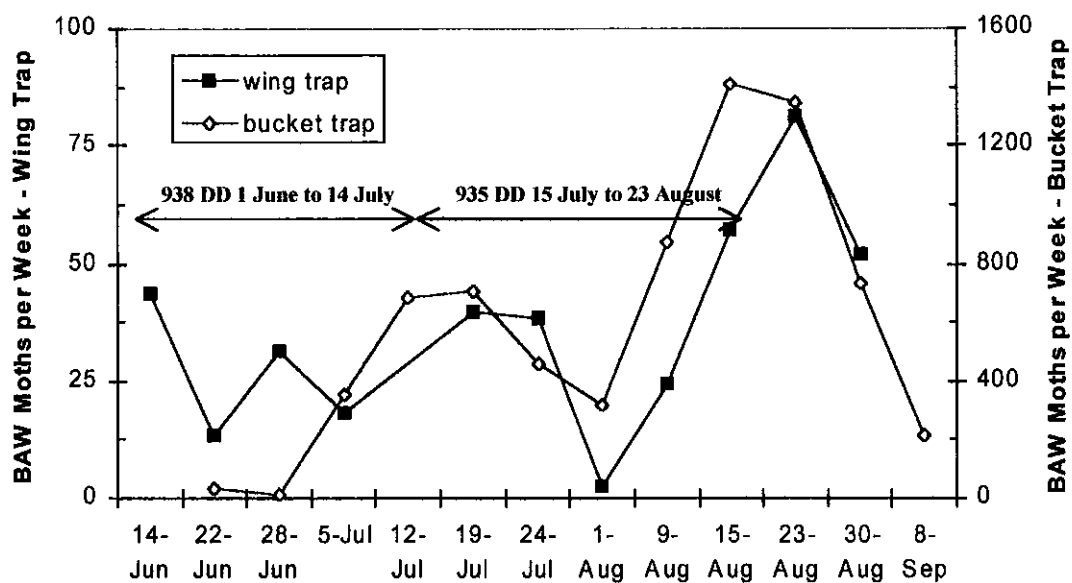


Fig. 1. Beet armyworm moth captures in wing and bucket pheromone traps; Fresno Co., 2000, degree day accumulations shown for reference.

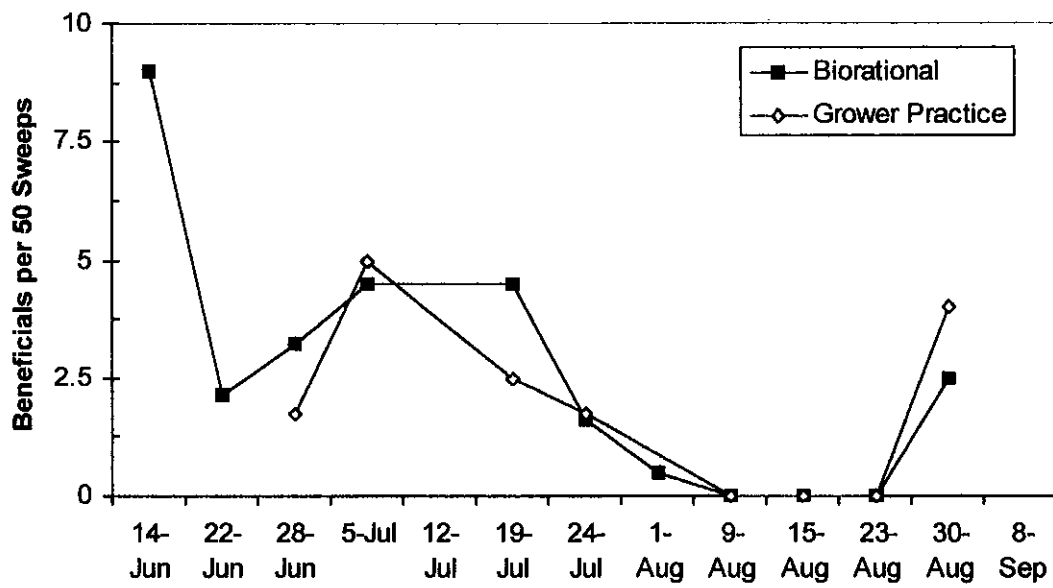


Fig. 2. Beneficial populations in from sweep net samples sugarbeet fields; Fresno Co., 2000.

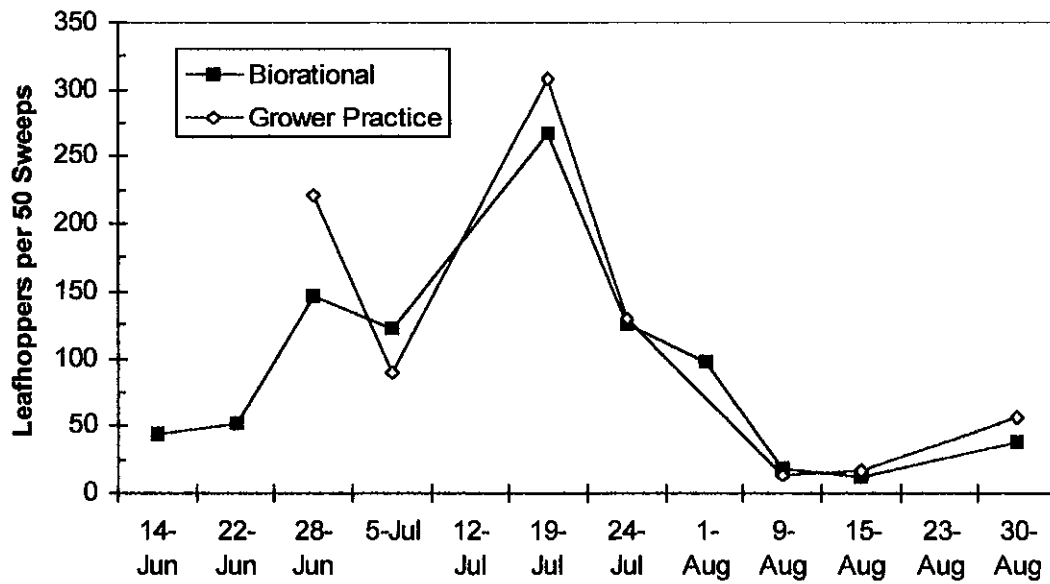


Fig. 3. Empoasca leafhopper populations from sweep net samples in sugarbeet fields; Fresno Co., 2000.

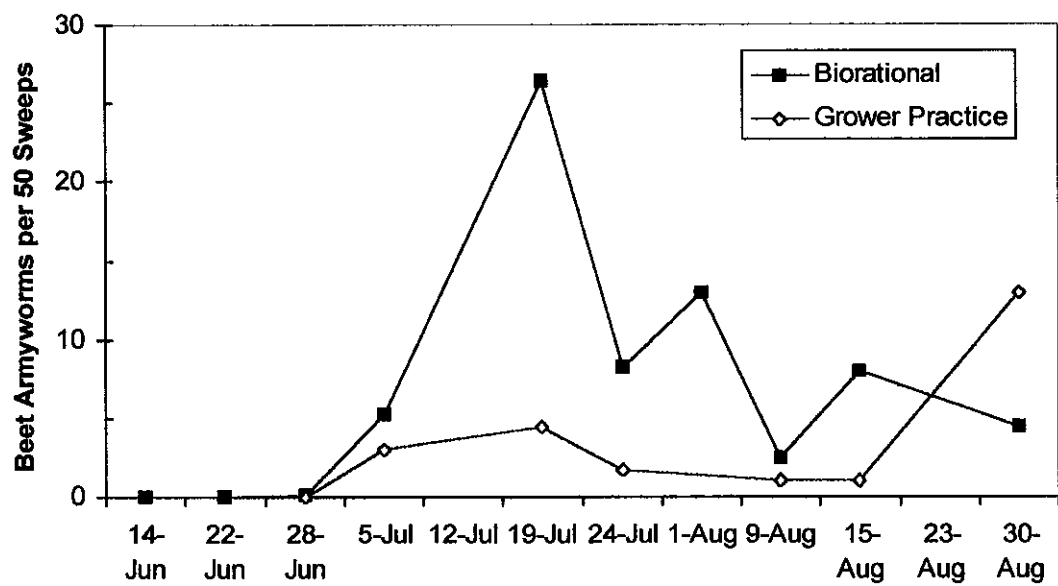


Fig. 4. Beet armyworm larvae from sweep net samples in sugarbeet fields; Fresno Co., 2000.

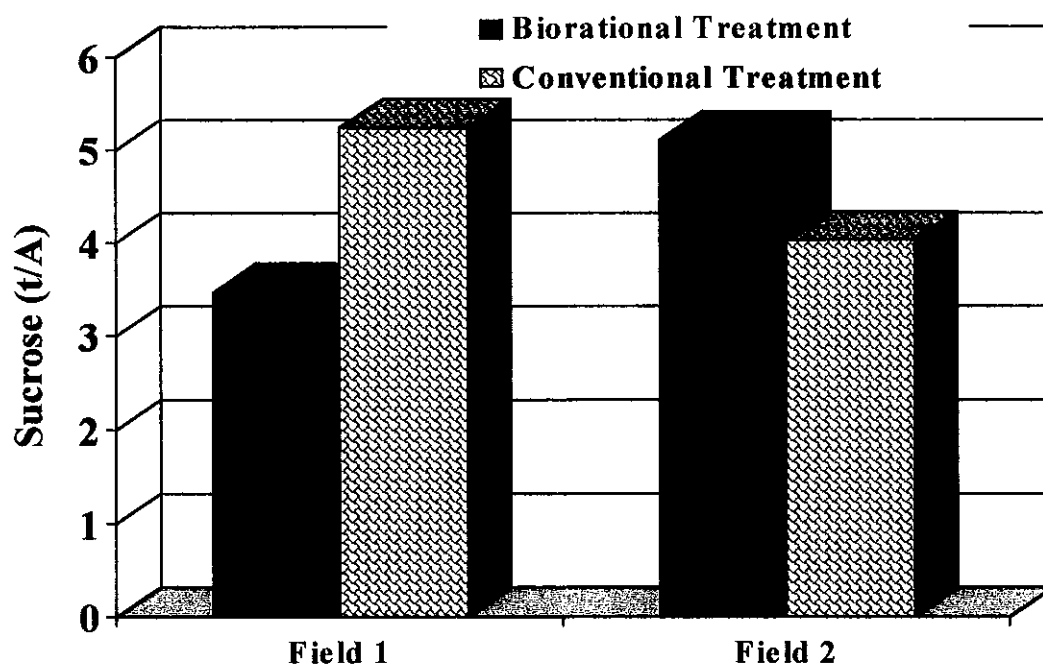


Fig. 5. Sucrose yields from sugarbeet fields with biorational and conventional treatments for beet armyworm management; Fresno Co., 2000.

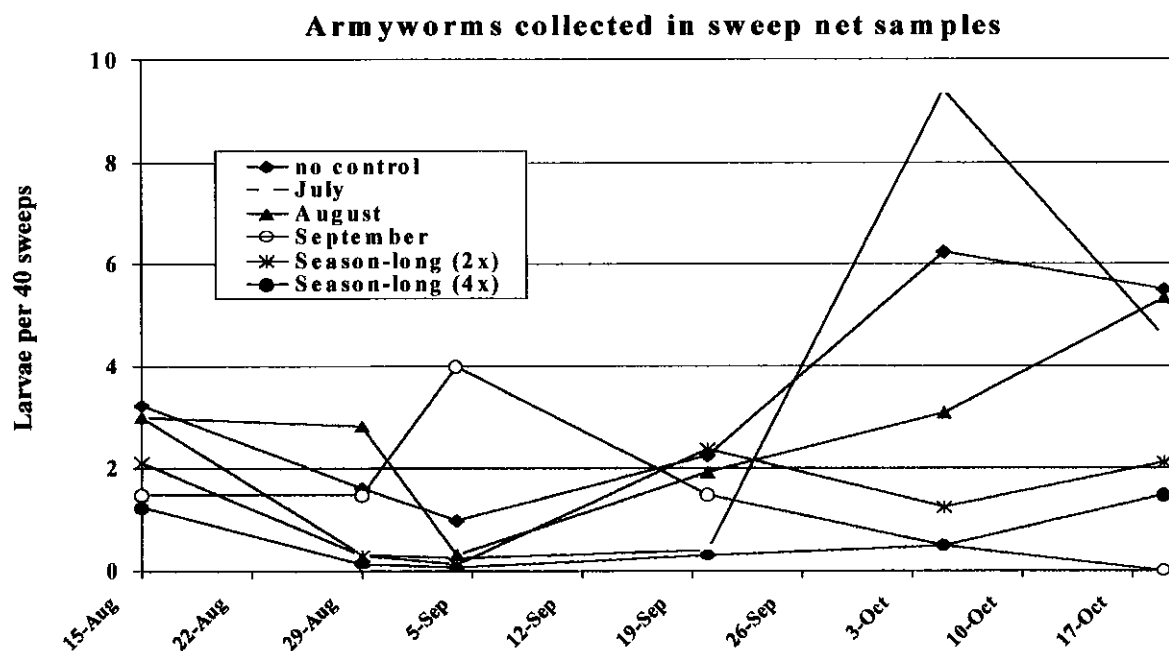


Fig. 6. Beet armyworm populations from threshold study in sugarbeets; Yolo Co., 2000.

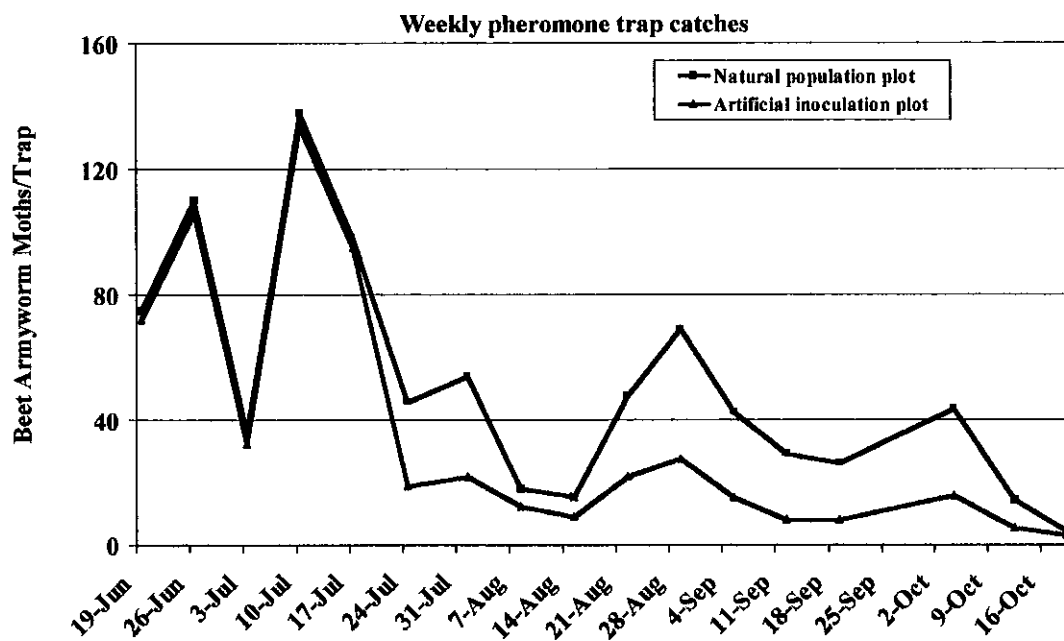


Fig. 7. Beet armyworm moth captures from wing pheromone traps placed in both threshold studies; Yolo Co., 2000.

Reduced Risk Management of Insect Pests in Sugarbeets

Objective 2: Work was not conducted due Imperial Sugar Company closures of the Woodland and Tracy processing plants. No beets were planted for spring harvest in this area in calendar 2000.

Reduced Risk Management of Insect Pests in Sugarbeets

Objective 3: Improving Sugarbeet Stands and Reducing Pesticide Use in the Imperial Valley: Stephen Kaffka and Thomas Babb

Summary

The effects of different methods of protecting emerging sugarbeet seedlings were compared in a field trial in the Imperial Valley. Treatments included the current preferred growers' practice involving the use of an insecticide at planting and four post-emergence sprays for insect control, seed treatment with a systemic insecticide at two rates (imidacloprid or Gaucho®), and no control of post emergence seedling damage. Seedlings were counted four times up until thinning. At harvest, stands were evaluated and yields were compared. Pre-emergence pesticide applications resulted in significantly larger numbers of seedlings than other treatments. Gaucho® was not as effective as the use of insecticides applied to soil and aerially up until approximately 2 weeks after emergence, but still resulted in adequate numbers of seedlings for a successful sugarbeet stand. Approximately 7 to 10 days after emergence, armyworm control became important, and an effective armyworm post-emergence insect control measure was probably required in Gaucho®-treated plots. Flea beetles were the principal cause of damage at emergence and are well controlled by Gaucho®, but it has no effect on armyworms. Some post-emergence insect protection remains important in the Imperial Valley when fields are irrigated early in the fall, but the amount may be reduced by using a seed treatment insecticide like Gaucho®.

Introduction

Sugarbeet production in the Imperial Valley is thriving. The reduction of chronic loss from lettuce infectious yellows virus and the improved performance of new sugarbeet varieties have led to world record sugarbeet yields over the last decade. Once established, sugarbeet plants grow well during the winter and spring months in the low desert. Planting takes place, however, during September and early October, when air and soil temperatures are above optimum, and the populations of insects preying on sugarbeet seedlings such as flea beetles and armyworms are large. Growers believe that control of insects on sugarbeet seedlings should commence as soon as seedlings appear and continue until after thinning approximately 40 days later. Otherwise, stand failure is considered certain. Management based on this assumption has been successful for many years, but the most commonly used materials for control (Lannate® and Lorsban®) are organo-phosphate type compounds which are currently under review by US EPA for possible future restriction under the provisions of the Food Quality Protection Act. Currently, there are no well-established alternatives to the use of these materials for sugarbeet seedling protection.

Methods

To evaluate alternative seedling protection strategies and document loss to insects and other causes, a trial was conducted in the Imperial Valley near Brawley in a 45 acre sugarbeet field. Fifteen strips,

each with 20 thirty-inch rows, were planted with Beta 4776R, a commonly planted variety in the area. All of the seed was from the same seed lot. Five different pre- and/or post emergence treatments were applied (Table 1). Each treatment was replicated three times. Emerging seedlings were counted in two twenty foot long subplots in rows 7, 8, and 9 in each plot, at 10, 16, 19, and 25 days after irrigation. At the last date, the above-ground portions of 30 seedlings were collected from row 8 of each subplot, dried and weighed for comparison.

Each seedling was labeled with a small wooden stake at emergence. The stake was removed later if the seedling died and the cause of mortality was evaluated visually in the field. If a plant was chewed off or obviously damaged by insects, its loss was attributed to the insect damage category, if it was shriveled or dessicated, or a common seedling pathogen could be visually identified, it was classified in the shriveled or diseased category. If there was no seedling next to a stake, it was classified as missing. Using stakes allows for the identification of the majority of seedlings appearing. Those disappearing during the first three or four days from the start of emergence will not have been counted. The sum of the number appearing is *cumulative emergence*. The last count, just prior to thinning was considered to be the *final establishment*. Because the amount of seed planted is known, *pre-emergence losses* can be calculated by difference using observed cumulative emergence. The field was planted on September 19 using a Monosem air planter. The amount of seed remaining after planting the field was weighed to get an exact weight for the seed planted. In this trial, 144,600 seeds per acre were planted. This was divided by the known field area to get the seed population. We assume that planting occurred uniformly. The seeding rate used was a high rate compared to the target root population at harvest of approximately 35,000 plants per acre and reflects the common growers' anticipation of low levels of seedling survival. Irrigation was initiated on September 19th following planting.

Herbicides are also used in a program of sugarbeet seedling protection. The most common and effective herbicide used is a selective material called Betamix® (phenmedipham+desmedipham). It is a photosynthesis inhibitor, and under conditions of intense light and high temperature, also can harm sugarbeet seedlings. Growers in the Imperial Valley report that if seedlings are damaged by insect chewing, Betamix® causes more damage to seedlings than otherwise, resulting in increased post-emergence seedling mortality. So an additional objective of insect control for the growers is the desire to avoid leaf injury leading to additional herbicide damage. Betamix® was applied to all plots on October 8th (day 16). Plots were counted immediately prior to application and then three days (day 19) and nine days later (day 25). Higher seedling losses in the shriveled or diseased category in treatments in which insects were not controlled compared to treatments in which they were should reflect insect-herbicide interactions.

Thinning was carried out with a mechanical, wheel-type thinner. The field was managed uniformly following thinning until harvest. At harvest, all the sugarbeet roots in two adjacent 150 foot long rows (rows 7 and 8 above) were counted and then harvested mechanically using a sugarbeet plot harvester. Two subsamples per plot were analyzed for sugar content and impurities. Plant populations at harvest were compared to plant populations prior to thinning the previous fall. Prior to harvest, the distances between the first 50 seedlings in row 8 were measured. These were

averaged and compared. Plant spacings were also classified into groups, based on the distance from their nearest neighbors, using a target or theoretical spacing at harvest. The *theoretical spacing* (TS) was estimated using the initial seeding rate (SR), adjusted for germination percentage (GP) (92 %) and combined thinning and post-thinning losses (TL).

$$TS = SR / \{0.92 * (1-TL)\}$$

This assumes that seed placement was uniform and thinning and post thinning losses were identical in all treatments. This is an approximation only, but allows for comparisons of the evenness of plant spacing among the treatments. When planting to a stand, for example, if a large emergence rate is expected, seeds can be spaced at close to the desired final distance and plant population. Large gaps are most likely to cause yield loss under these conditions. Treatments were compared based on the percentage of plants separated from their neighbors by a distance 1.5 times greater than the theoretical spacing. This method of comparison is based on methods of evaluating planter performance proposed by Kachman and Smith (1995).

Results

Cumulative emergence. Seedling survival was greatest when pre-emergence insecticides were used (Table 2). There was no significant difference between the Grower's treatment using pre-emergence Lorsban® applied to the soil and seed treated with Gaucho® (Table 3). Emergence was delayed slightly, however, by the Gaucho® treatment, which is known to slow emergence (fig. 1). Substantially fewer seedlings emerged in all the other treatments lacking pre-emergence insecticides (Table 3). *Pre-emergence losses* are determined by difference (Table 2). Average pre-emergence losses of all seed planted were approximately 20% in treatments receiving insecticides, and 42 % in those not. The germination percentage of this seed lot was 92 %. Accounting for non-viable seed (minus 8 %), reduces estimated pre-emergence losses to approximately 11 % of the viable seed for the treatments receiving insecticides and 35 % for all the other treatments.

Establishment at thinning. The percentage of seeds resulting in established seedlings immediately prior to thinning (approximately six true leaves) is reported in Table 2. The average number of seedlings counted at each date is also presented in figure 2. There was no significant difference between the Growers and Gaucho® treatments, but all other seed treatments resulted in significantly less (Tables 2 and 3), and approximately similar numbers of seedlings. The Growers treatment remained largely constant. In the Gaucho® treatment , they increased and then decreased slightly, while in the untreated plots, seedling numbers declined steadily with time (fig. 2).

Cumulative mortality. In the Growers treatment, there was very little post-emergence seedling loss up to thinning (Table 2, figure 3). Mortality increased with time in all other treatments. There was significantly greater post emergence mortality in Gaucho®-treated plots than in the Growers treatment (Table 3), though the absolute difference was small (Table 2). Insects, plant diseases, and possibly herbicide damage all contributed to seedling loss.

Seedling growth. The dry weight of seedlings at thinning is compared in Table 4 and figure 4. The Growers treatment resulted in the largest seedlings, but seedling DW was not significantly different from Gaucho® treated seeds. All other treatments resulted in significantly smaller seedlings. From initial emergence onwards, flea beetles were present in the plots and damaged seedlings, even at the cotyledon stage. Later, armyworm larvae appeared, and began to damage seedlings as well. The Bt treatment seemed to provide marginal protection to the seedlings, and there was a non-significant trend towards larger seedling dry weight, suggesting that some inhibition of armyworm growth may have occurred. Gaucho® treated plants were smaller than the plants that were sprayed frequently. Gaucho® is not effective against armyworms and increasing damage with time occurred as armyworm larva grew and consumed seedlings. This damage may have continued for a period after thinning, because Gaucho® treated plots resulted in fewer plants and larger distances in the row between plants than the Growers treatment at harvest (Table 5).

Plant populations at harvest. Plant populations were largest in the Growers and Gaucho® treated plots, and lower in the others (fig. 5). Plant spacing differed significantly among the treatments and followed the patterns established primarily at emergence the previous autumn (Table 5). The treatments with the greatest number of large gaps were those with the poorest overall seedling establishment levels the previous fall (Table 5).

Yield. Yield was proportional to root weight and inversely proportional to plant population at harvest. Yields were lowest in the Growers treatment (fig. 6, 7). Because of plant over-crowding, the treatments that had the fewest surviving plants at harvest had the largest yields. These were the same treatments that resulted in the largest early season total mortality. There were no significant differences in sugar percent among the treatments (fig. 8) or in impurities or recoverable sugar (not shown).

Discussion.

Plant protection. In the Imperial Valley, and other locations where pre-emergence losses are high, an insecticide applied with or to the seed appears necessary. Pre-emergence losses were three times greater among treatments that did not include an insecticide with the seed.. The significantly larger number of seedlings emerging and becoming established in treatments including a pre-emergence insecticide in this trial leads to the inference that insect damage is occurring to seeds and emerging seedlings before they appear above ground. If widespread, this is a new observation in California. Such damage has been reported in England and elsewhere in Europe, where *Collembola sp.* are sometimes implicated in losses (Durrant, et al., 1988) but has not been reported before in California. Alternatively, losses of newly emerged seedlings to flea beetle grazing or other insect predation may have occurred prior to the first observation at day nine after irrigation. However, in many other recent trials elsewhere in California where flea beetles have been present, early post-emergence loss to insects or diseases (1 to 3 days from the onset of emergence) has been rare. We do not consider them likely here. Early seedling damage was due almost entirely to flea beetles. Armyworm larvae had not had time to develop and were not observed.. Gaucho® is very effective against flea beetles,

and substituted well for soil applied Lorsban® and the first and possibly the second aerial applications of Lorsban®, as well. This is a significant savings in pesticide use.

In addition to having adequate numbers of seedlings, growers need healthy, vigorous plants. Treatments not receiving a pre-emergence insecticide resulted in severely damaged seedlings by the last counting date. Those seedlings surviving were reduced in size, often having damage to the apical meristem region. Even the Gaucho® treated seedlings were smaller and were beginning to suffer armyworm damage at the last counting date, suggested both by lower seedling weights (Table 3) and increasing rates of mortality (figure 4). These losses resulted in fewer plants at harvest and greater variability in plant spacing compared to fall population estimates and compared to the Growers treatment (table 5). They imply that some post-emergence worm control is necessary in the fall establishment period. Compared to the standard growers treatment, however, the amount of pesticide and the number of treatments needed could be reduced, if these results prove to be characteristic.

Xentari® (Bt) was not very effective as a post-emergence worm control practice. It has no effectiveness against flea beetles, the principal pest during the earliest stages of growth. Other, newer botanicals or low impact insecticides may be combined with Gaucho® in the future, however, to form a complete alternative to currently used organophosphate and carbamate insecticides.

Costs of establishment. The percentage of seed resulting in established seedlings was high in this trial when pre-emergence insecticides were used. Generally, when 70 % or more of the seed planted results in viable plants, sugarbeets can be planted to a final stand density, and hand thinning is no longer needed. Hand thinning costs in the Imperial Valley typically average between \$50 and \$100 per acre. In addition, seed is over-planted by approximately three times the needed amount, if the emergence rates observed in the best treatments in this trial can be repeated in most locations. With seedling protection in this trial, money could have been saved and several pesticide applications spared.

Yield. Mechanical thinning, applied uniformly across all treatments, left too many plants unthinned. A large population of roots survived until harvest (fig. 5). Average losses from thinning until harvest (including the thinning process itself) equaled 41% of the seedlings in all treatments. Because of very large populations, many small roots were present at harvest in treatments 1 and 2, but these could not be gathered by the harvester and were lost, skewing the yield comparison.

Of particular interest, however, was the observation that treatment 3, which received no insect control of any kind, resulted in a good commercial yield. There were no seedlings in the untreated test plots that escaped damage by insects, but even in uncontrolled plots sufficient seedlings survived to develop into healthy sugarbeet plants and provide good yields. This result contradicts conventional wisdom that there would be no useful plant stand without insect control, and occurred despite the observation that the autumn of 1999 was notable for severe armyworm pressure. It is also a testimony to the inherent toughness of sugarbeet seedlings once emerged.

Limiting the results of this experiment, however, was the irrigation date. This field was initially irrigated during the middle of the sugarbeet planting period in the Imperial Valley. Growers begin irrigating the earliest sugarbeet stands at the end of the first week of September and it is a common observation that the earliest stands are the most severely damaged by insects. Our results do not reflect the consequences of applying these seedling protection treatments at the earliest planting date possible. Additional tests started earlier in the year are needed. Our results do suggest, however, that fields initially irrigated even later in the season than this field may need less pest protection than previously thought necessary, and that later planting is itself an alternative management technique.

Plant spacing at harvest. Yield was not a useful way to compare the different treatments applied in this trial. Thinning was inadequate to allow roots to develop to full size in some of the treatments. Yields suffered as a consequence. For a grower concerned about establishing a uniformly spaced stand, the number of large gaps at harvest compared to the target population is the most important consideration. This can be determined by evaluating the number of plants in the population with spacings greater than 1.5 times the target population. The proportion of plants at harvest greater than 1.5 times the target spacing lowers average yields in a field because of lost light capture by the plant canopy. In this trial, treatments 1 and 2 had fewer large gaps (Table 5). If an Imperial Valley grower were interested in attempting to plant to a stand, soil or seed applied insecticides are essential.

Conclusions

1. Pre-emergence pesticide applications resulted in significantly larger numbers of seedlings than other treatments.
2. Gaucho® applied to seeds worked as well as Lorsban® applied to soil and aerially immediately after emergence. Flea beetles were the principal cause of damage at emergence and are well controlled by Gaucho®. Approximately 7 to 10 days after emergence, armyworm control became important. At this point, an effective post-emergence insect control measure was probably required in Gaucho®-treated plots.
3. Establishing a large percentage of seeds as seedlings both saves growers money on seed costs and reduces the amount of pesticides applied, with imputed environmental benefits.
4. Some post-emergence insect protection remains important in the Imperial Valley when fields are irrigated early in the fall, but the amount may be reduced by using a seed treatment insecticide like Gaucho®.
5. Despite the survival of unprotected seedlings in this trial, it would be incorrect to conclude that no seedling protection is necessary. Growers cannot risk a large financial investment in crop production when they have the opportunity to protect that investment. Reduced spraying based on economic thresholds or knowledge of probable damage is far different from leaving the fate of seedlings to chance, and depends upon the use of remedial measures like insecticides as necessary.

Table 1
Treatments

Number	Description	Pesticides used	Timing (Days since first irrigation)	Rates	Type of application	Cost (\$/ac)
1	Standard practice in the region (Growers')	Lorsban® 15G	-2	4.6 lb/ac	Soil applied with seed	8.92
		Lorsban® 4E	7	1.15 pt/ac	Aerial	15.84
		Lorsban® 4E	10	1.18 pt/ac + 0.59 pt/ac	Aerial	16.65
		+	17	1.06 pt/ac + 0.88 pt/ac	Aerial	16.87
		Diazanone 4E	22	1.06 pt/ac + 0.88 pt/ac	Aerial	<u>16.87</u> 73.49 (total)
2	Seed applied systemic insecticide (Gaucho®)	Imidacloprid (Gaucho®)	Applied to seed prior to planting	45 g per 100,00 seeds; 67.5 g per acre.	With seed	72.34 (total)
3	No pre- or post-emergence treatments (Control)	none				
4	<i>Bacillus thuringiensis</i> application post-emergence (Bt)	Xentari®	7	1.25 lb/ac	Aerial	22.82
			10	1.25 lb/ac	Aerial	22.82
			17	1.25 lb/ac	Aerial	22.82
			22	1.25 lb/ac	Aerial	<u>22.82</u> 91.28 (total)
5	One application of standard pesticide (1X)	Lorsban® 4E	7	1.15 pt/ac	Aerial	15.84 (total)

Table 2
Seedling emergence and establishment

Treatment	Cumulative emergence	Cumulative mortality (% of seed sown)	Cumulative mortality (% of plants emerged)	% established	Diseased (% of seed sown)	Diseased (% of plants emerged)	Insect loss (% of seed sown)	Insect loss (% of plants emerged)	Pre-emergence loss (%)*
<i>Grower's</i>	82.2	2.7	3.5	79.3	1.2	1.6	0.1	0.2	17.8 (9.8)
<i>Imidacloprid</i>	79.4	5.1	6.9	74.1	3.0	4.3	0.8	1.1	20.6 (12.6)
<i>Control</i>	56.3	8.1	15.6	47.5	4.4	10.0	1.7	3.2	43.7 (35.7)
<i>Bt</i>	55.6	5.5	7.1	49.7	3.0	6.4	0.7	1.5	44.4 (36.4)
<i>Control + Lorsban® (1x)</i>	58.2	6.2	11.5	51.6	3.8	7.8	0.7	1.3	41.2 (32.2)

* Includes 8 % non-viable seed. Values adjusted for non-viable seed are in (). Additional viable seed may have remained un-emerged in the soil, but this seed is of no agronomic significance and is regarded as lost.

Table 3**Treatment contrasts (Days since initial irrigation = 25, final count)**

Treatments*	Variables	SS	F	p =
<i>Growers vs Gaucho®</i>	Cumulative emergence	160.4	0.56	0.4556
	Number established	584.4	1.86	0.1756
	Cumulative mortality	148.1	6.84	0.0106
<i>Control vs Bt and 1X</i>	Cumulative emergence	10.7	0.04	0.8469
	Number established	277.1	0.88	0.3498
	Cumulative mortality	176.3	8.15	0.0054
<i>Pre-emergence insecticide vs control (1+2 vs 3)</i>	Cumulative emergence	17226.8	60.3	0.0001
	Number established	24390.0	77.82	0.0001
	Cumulative mortality	602.1	27.83	0.0001

*See Table 1 for treatment descriptions

Table 4 Seedling dry weights at thinning (g DW per 30 seedlings)	
Treatment	Dry weight (g)
Grower's	5.75
Imidacloprid	4.97
Control	2.42
Bt	3.87
Control + Lorsban® (1x)	3.22
LSD _(0.05)	(1.51)

Table 5
Plant population comparisons

Treatment	Max. emergence rate*	# of plants at thinning	Target population after thinning	# of plants at harvest	Ave. plant spacing in row at harvest	Standard deviation of spacing	Portion of row with large gaps **
		(plants per foot)			(inches)		(%)
<i>Growers'</i>	7.7	6.6	4.5	3.8	2.8	1.8	21.3
<i>Imidacloprid</i>		6.2		3.1	3.8	2.3	39.3
<i>Control</i>		4.0		2.7	4.5	3.2	50.7
<i>Bt</i>		4.1		2.5	5.0	3.8	57.3
<i>Control + Lorsban® (1x)</i>		4.3		2.5	5.4	5.0	53.3
<i>LSD_(0.05)</i>		0.59		0.47	0.77		

* Adjusted for non-viable seed. **1.5 x greater than the target spacing, (2.7 inches).

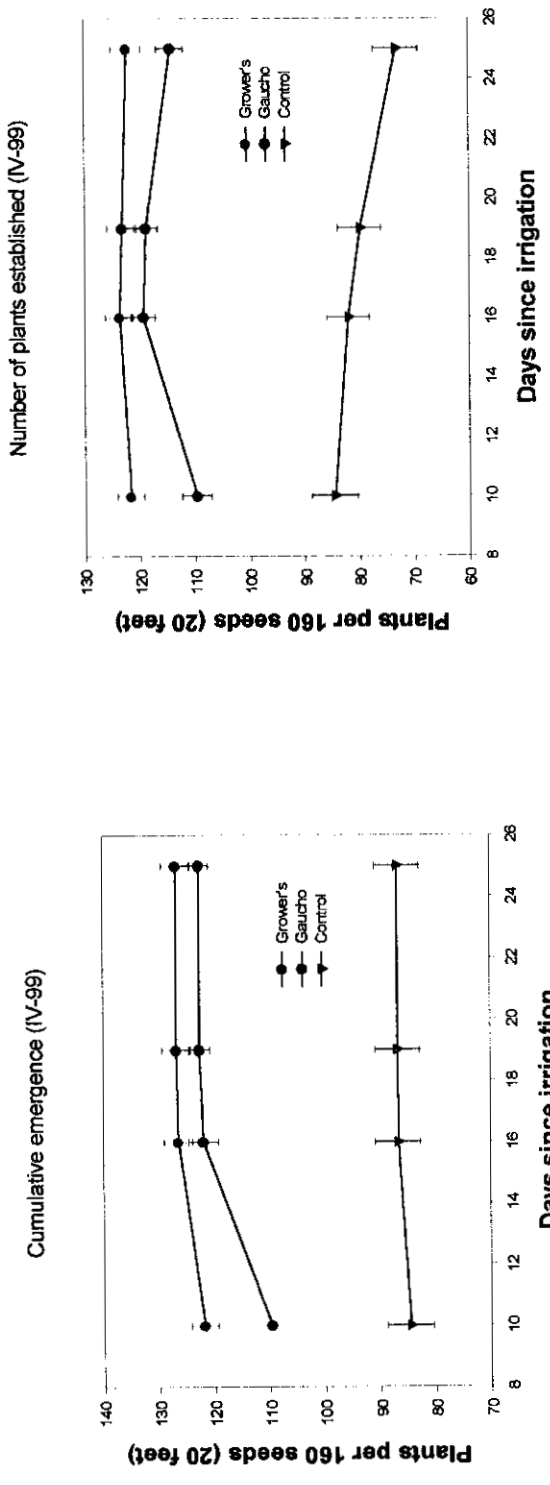


Fig. 1. Cumulative emergence at thinning

Fig. 2 Number of plants at each counting date

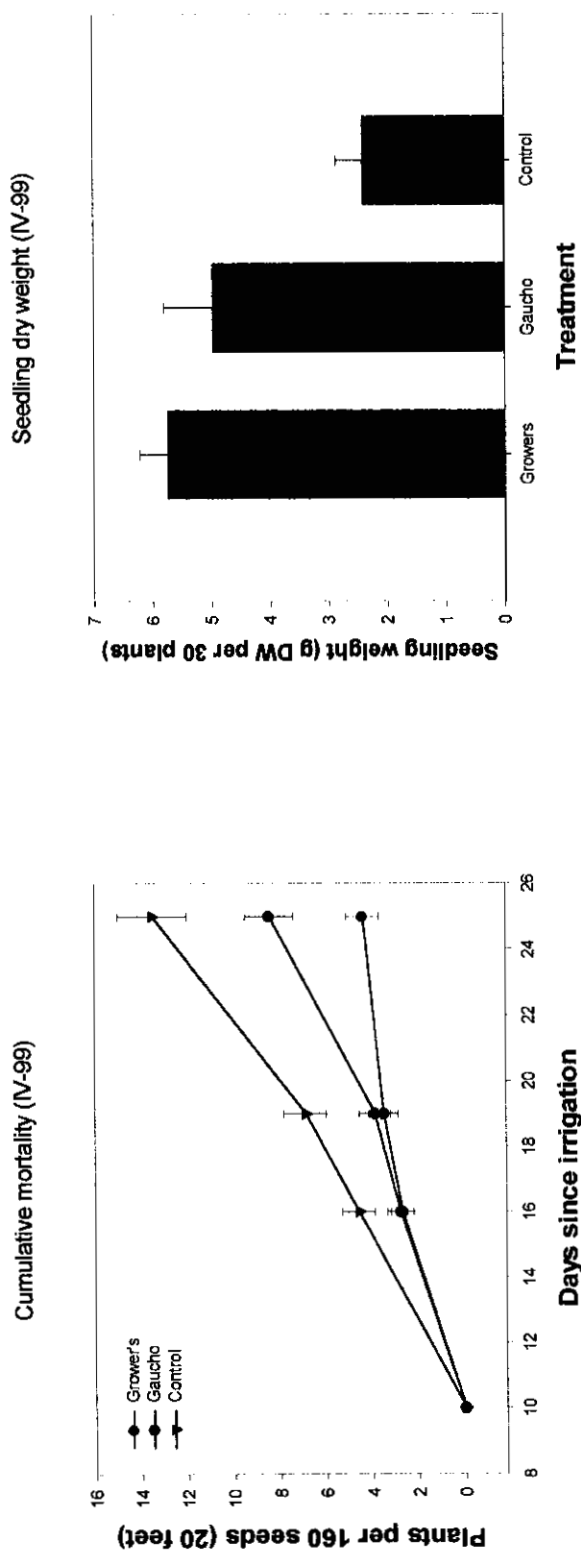


Fig. 3. Cumulative mortality

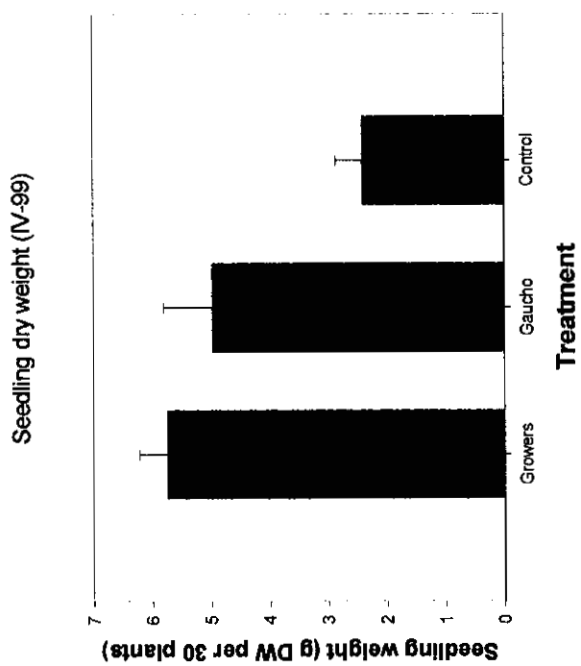


Fig. 4 Seedling dry weight at thinning

Fig. 5 Root populations by treatment

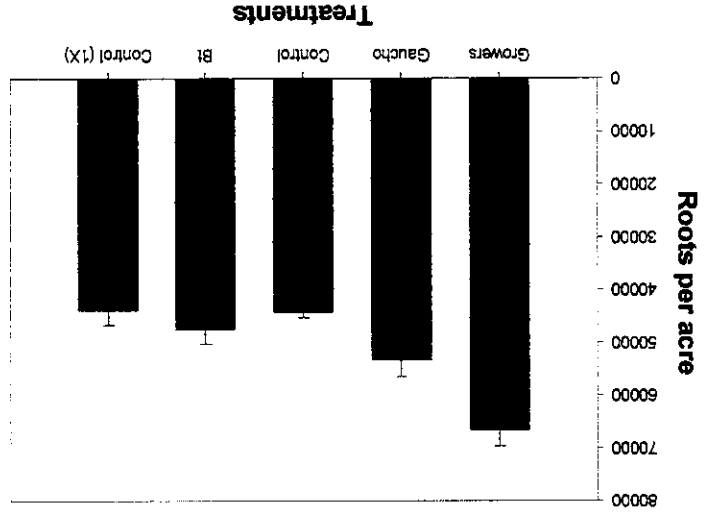
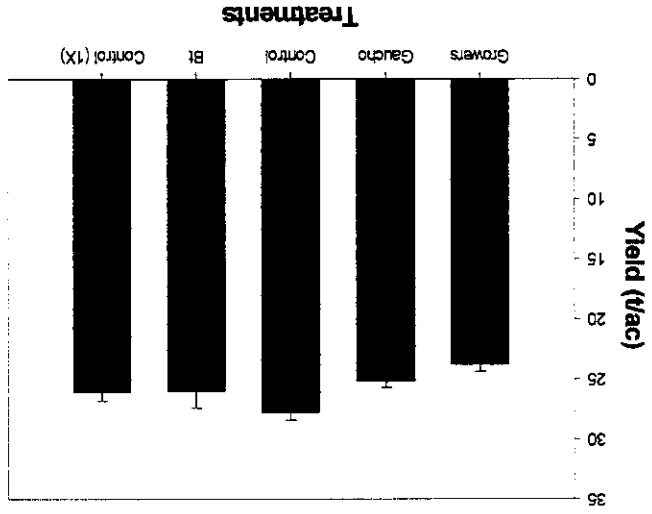


Fig. 6. Root yield by treatment



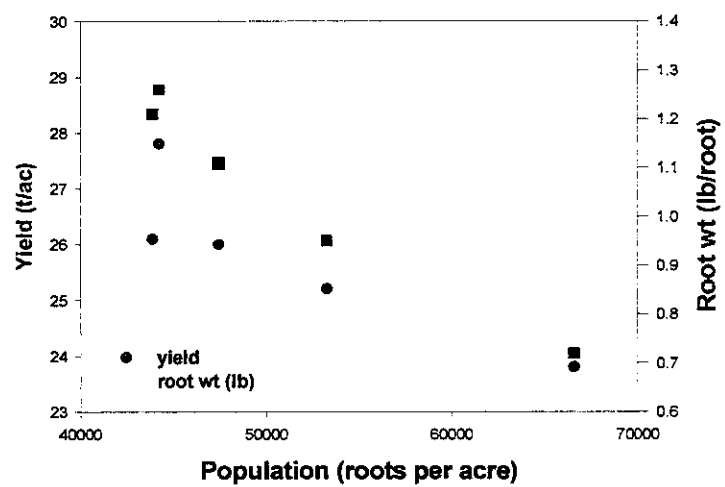


Fig. 7 Yield, root population and single root weight

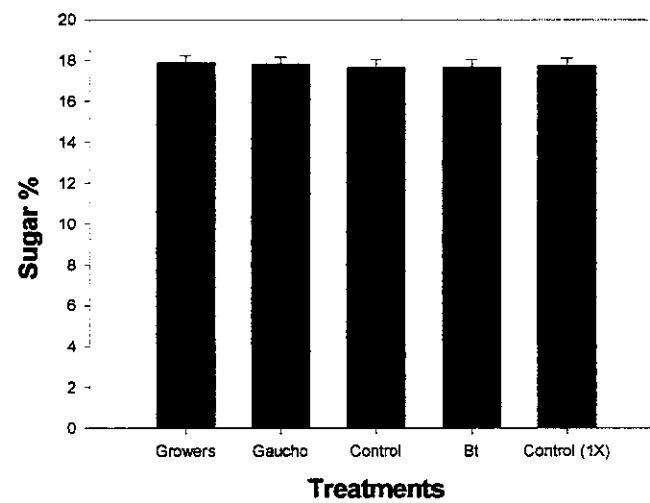


Fig. 8. Sucrose content by treatment

Reduced Risk Management of Insect Pests in Sugarbeets

Objective 4: Improving Pest Management Decisions with Internet Accessible Keys to Pest Damage, Pests and Beneficial Insects and Links to Reduced Risk Pest Management Options:

Results from tasks 1 through 3, under objective 1, have been placed on the statewide sugarbeet web site (<http://agronomy.ucdavis.edu/sweettimes>) . A special button on the web site links the user directly to the Pest Management Alliance results page. There the viewer will find the reports sent to the Department of Pesticide Regulation. Links to the UC IPM web site which discusses best pest management guidelines also are available as well as links to other sites around the U.S. and the world. Currently, growers and pest control advisors can view results and see photographs of the insect species damaging beets and the type of damage observed in the field.

Formal pest management keys and recommendations complete with links to the UC IPM web site and additional photos are being developed and will be modified over the next year to reflect additional experiences with demonstrations in the San Joaquin and Imperial Valleys.

The web site with information about the Pest Management Alliance program will be introduced to growers and PCA's at an upcoming meeting of Pest Control Advisors in Imperial Valley in May.

In future years, as additional demonstrations are completed, pest management recommendations on the web site will be changed to accommodate results from demonstrations supporting IPM objectives for reduced risk pest management.

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LIST OF PUBLICATIONS PRODUCED

Kaffka, Stephen, Babb, Thomas, Godfrey, Larry. 1999. Protecting Sugarbeet Seedlings in the Imperial Valley. Sugarbeet Notes, December 1999, No. 8.

Kaffka, Stephen. 2001. Alternative Approaches to Sugarbeet Seedling Protection in the Imperial Valley Appear Promising, The California SUGAR BEET, pp 15-19.

APPENDIX A

PRESENTATIONS FROM PMA PROJECT

Kaffka, Stephen, Godfrey, Larry, Goodwin, Ben. Results discussed at the U.C. Sugarbeet Work Group meeting. January 2001, U.C. Davis, Davis, California.

Godfrey, Larry, Goodwin, Ben. Results presentation at California Beet Growers Association District No. 6 Annual Meeting (Fresno County). November 9, 2000, Fresno, California. "Sugarbeet Pest Management Alliance: Reduced Risk Management of Insect Pests in Sugarbeets."

Godfrey, Larry. PMA project poster presentation at the meeting of the Entomological Society of America. December 2000, Montreal, Quebec, Canada, and American Society of Sugarbeet Technologists, March 2001, Vancouver, British Columbia, Canada. "The Establishment of Economic Injury Levels for the Beet Armyworm in California Sugarbeets."

An abstract will be published from the American Society of Sugarbeet Technologists meeting under the same title as the poster presentation.

Kaffka, Steve. Scheduled presentation for introduction of web site information on the Pest Management Alliance program to be made to growers and PCA's at the Pest Control Advisors meeting, Imperial Valley, May 2001.